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## Safety Management of Complex Research Operations

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**NASA**

# **SAFETY MANAGEMENT OF COMPLEX RESEARCH OPERATIONS**

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## **SUMMARY**

Complex research and technology operations present many varied potential hazards which must be addressed in a disciplined independent safety review and approval process. The research and technology effort at the Lewis Research Center is divided into programatic areas of aeronautics, space and energy. Potential hazards vary from high energy fuels to hydrocarbon fuels, high pressure systems to high voltage systems, toxic chemicals to radioactive materials and high speed rotating machinery to high powered lasers.

A Safety Permit System presently covers about 600 potentially hazardous operations. The Safety Management Program described in this paper is believed to be a major factor in maintaining an excellent safety record at the Lewis Research Center.

## **INTRODUCTION**

A research center with many varied and complex research operations will experience potential hazards in the office, shop, laboratory and research test facility. A safety program must be structured to address all of these areas, with primary emphasis on people safety. However, research facility and test equipment also require a sound safety approach to safeguard the accomplishment of the research program mission. Over 30 years ago, the Center Management formed the Lewis Safety Organization to address the safety and health needs of the Center. The safety program was built on the premise that line management is responsible for the safety of its operations and independent safety review and approval would be required of all potentially hazardous research operations. A formalized systems safety approach was developed where the researcher formulates a safety plan that is implemented through the research program phases.

This paper describes a safety management program which has been considered quite successful over the years in minimizing the high attendant risks for conduct of research. Other research centers have reviewed this program in the past and have adopted certain aspects to their respective operations. If this paper generates ideas and assists others in the formulation of a research center safety management program, then it has accomplished its primary goal.

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\*Safety Officer.

## LEWIS RESEARCH CENTER, COMPLEX RESEARCH & TECHNOLOGY

In 1942, the National Advisory Committee for Aeronautics broke ground adjacent to Cleveland Hopkins Airport for the third of its Research Centers. The Center's small staff was given the responsibility of conducting research on reciprocating and turbojet engines and on rocket propulsion systems. In October 1958, NACA became the nucleus of the National Aeronautics and Space Administration. The Lewis Research Center (LeRC), today, is one of 11 Centers of the National Aeronautics and Space Administration (Figure 1). LeRC now employs about 3,000 people and continues as a World leader in advanced propulsion and power research and technology.

The Center's Charter, energy conversion research and technology (Figure 2), is divided into the three main areas of aeronautics, space and terrestrial applications. An example of the complex research and technology in aeronautical propulsion can be seen in the areas of internal aerodynamics, system interactions, materials and components (Figure 3).

The test facilities at LeRC are located on 350 acres and represent a real property investment of 300 million dollars with an estimated replacement cost of about one billion dollars. There are over 100 buildings on the Center and 550 specialized research installations. An example of small and medium size research installations is shown in the Engine Research Building which contains about 65 test cells (Figure 4). Major test facility complexes include the Propulsion Systems Lab 3&4 (Figure 5), 10x10 foot and 8x6 foot Supersonic Wind Tunnels, Space Environment Tanks, Icing Research Wind Tunnel, Rocket Engine Test Facility and the High Pressure Turbine and Combustor Facility. This varied research and technology complex presents many potential hazards; for example, hydrocarbon fuels, cryogenic fuels and oxidizers, high voltage, high pressure and high temperature containment vessels, hard vacuum systems, high speed rotating machinery, radioactive and toxic materials and lasers.

### SAFETY PROGRAM ORGANIZATION

Over 30 years ago, the Center recognized the need for a Safety Organization which could effectively evaluate and address the many varied potential hazards. The key elements of this organization, which cover operations that are diverse and change frequently, are shown in Figure 6. At the top of the list is management support for the safety in day-to-day operations. Management must provide a visibility into the operations of a research center wherein risk assessments are balanced against the applied resources and performance objectives.

A major element of a safety organization is that it must provide a consistent safety policy that applies to all aspects of the research center operations. The systems safety approach is also a vital key element where the research facility system must be reviewed and analyzed through a discipline of systems safety techniques. Also, the Safety Organization must be staffed with professional scientists -

engineers and technical support personnel with appropriate experience and training to perform the safety review task. Another key element is the independence of its members from direct in-line responsibilities of the research operation subject to safety review. This independence provides a fresh look, first-time visibility and provides for a safety approval process separate from line organization responsibilities. A final key element is a documented safety review-approval process for each research operation with potential hazards. A formal system provides a communication medium to all concerned on the status of the safety review and approval process.

The Lewis Safety Organization (LSO) is staffed with 160 personnel of which 25% are full time and the remaining 75% are part time or collateral-duty personnel. The full time staff, about 40 personnel, are located in the Safety Office, Occupational Medicine, Office of Environmental Health and Plant Protection (left side of Figure 7). Safety areas covered include industrial safety, medical services and industrial health, environmental health and emergency firefighting-personal injury response. The collateral duty personnel, about 120, provide staffing for the Executive Safety Board, Advisory Panels, Accident Investigation Committees and Area Safety Committees (right side of Figure 7). The primary function of the Executive Safety Board is to serve as the Center safety policy and decision making Board. The Board, staffed with Senior Management officials, establishes and maintains the system of safety committees, advisory panels and investigating committees and acquaints the Director with any significant major risks. The Environmental Pollution Control Board is staffed and functions in the same manner, only it covers environmental health and pollution concerns. The heart of the LSO is the safety committee. The Center plot plan was divided into eight geographical areas with boundaries (Figure 8), such that each area includes a complex of facilities with a degree of operational similarity and manageable from a safety control standpoint. A safety committee is assigned to each geographical area (1-8), to review major process systems (Process Systems Safety Committee) and major Center electrical systems (Electrical Systems Applications Safety Committee). The safety committees are responsible for reviewing all proposals for research operations, facilities or equipment with attendant potential hazards and approve/issue safety permits for accepted proposals. The safety committees also submit to the Executive Safety Board any significant risks or safety concerns.

A typical safety committee is staffed with six to eight employees on a collateral duty basis. The committee chairman determines the size and composition (mix of skills) that is appropriate for his committee's area of systems responsibility. Committee members are chosen with good technical credentials in such areas as experimental test operations, research, test facilities and systems engineering. At least one member should have a detailed knowledge of the committee's geographical area of cognizance. However, the committee member's immediate primary duties should, in general, not place him in a conflict of interest situation with the safety committee activity. This is very important in keeping the safety review and approval independent from the research or project line management.

## SAFETY REVIEW AND APPROVAL PROCESS

It is the responsibility of LeRC employees assigned to a system or operation to insure that its design and operations are safe. The personnel involved in the safety review and approval process represent either the requestor or the safety approval body. The requestor could be the researcher, project or test operations engineer (Figure 9). The safety committee conducts the safety review and can obtain advisement such as industrial safety and environmental health from the Safety Office, Advisory Committees, Environmental Health and the Lewis Safety Officer, as needed.

The phasing of the safety review process with the research test program is very important (Figure 10). When research has decided to undertake a new activity, the conceptual design agreed upon and the facility site is selected, the responsible organizational element (requestor) contacts the Safety Committee Chairmen for a meeting. At the initial meeting, the requestor describes the conceptual design, siting considerations, outline of operational hazards, etc. The committee responds by indicating the nature and detail of documentation, analysis, etc., it will require to accompany a formal request. The safety committee may also advise the requestor to consult with the safety, medical, environmental health or plant protection personnel for appropriate advisement. The key element is early notification and continuing communication with the safety committee through incremental progress meetings.

The development of supporting documentation which constitutes an overall safety plan is the responsibility of the requestor for a safety permit. The documentation should be sufficient to permit the safety committee to understand and assess the hazards that are involved with the research operation, the safety standards applied and the planned operational safeguards. In general, the amount or extent of supporting documentation necessary depends on the complexity of the experiment, the degree of risk and severity of failure.

One of the most important elements of a typical systems safety plan (Figure 11), is the hazards identification analyses. There are many types of hazards analysis which can be applied depending on the type and degree of information available, complexity of system, program phase, type of analysis desired and available resources. A brief description of types of hazard analyses, data required and applicability to program phase are provided in Figures 12 and 13. As noted, each technique produces unique results and should be applied at the appropriate time in the project phase. The depth and sophistication of the systems safety plan will depend a great deal on the complexity of the research system. Obviously, a simple bell jar type bench test would not involve as much detail as a gas turbine engine test in a major test facility.

## SAFETY PERMIT SYSTEM

At the Lewis Research Center, a project engineer cannot operate any potentially hazardous operation without a Safety Permit (SP).

The Safety Permit (Figure 14), can only be issued by the Chairman of a Safety Committee. In applying for a safety permit, the requestor (project engineer) must fill out a Safety Permit Request (SPR) (Figure 15 and 15A). These forms are designed to provide a thumbnail sketch of the research test activity through a brief listing of test conditions, hazardous materials, discharge products to the environment, and applicable safety precautions. The SPR must be signed by requesting Division Chief, which provides a visibility to line management of the potential risks to be encountered.

An activity flow chart for the SPR (Figure 16) describes the review-approval sequence for any new research test activity. Once the Safety Permit is issued, the research test operation can commence. The Safety Permit provides safety approval for a one-year period of operation. The requestor is notified three months prior to expiration that renewal is required if the research test program is expected to continue. The renewal process follows the same activity sequence using a renewal request form, only the safety review consists of an on-site visit between two safety committee members and the requestor.

An automatic data processing (ADP) system is used to log and track the status of safety permits on a monthly basis. This system notifies the requestor prior to safety permit expiration that renewal must be initiated. If renewal is not requested prior to expiration, the ADP system sends out a notice to cancel the safety permit and remove the permit from the test cell posted location. There are, at present, about 500 safety permits in force at the Center covering many various large and small research test operations.

#### CENTER SAFETY OVERVIEW

An overview of research test operations is reported in the monthly Facility Utilization Report (Figure 17). It provides a snapshot of the operational status for all research test rigs and facilities on the Center with a compilation of known hazards. If potential hazards are summed at this particular time, they would include 328 high voltage/high amperage operations, 89 hydrogen operations, 18 activities employing 450 psi combustion air, 149 operations using natural gas, 144 with high speed rotation, 174 operations with hydrocarbons and 36 laser operations. Out of 1179 activities reported, 102 are designed for unattended operations.

If, at any point in time, a survey is required of research test operations which exhibit a particular hazard such as hydrogen, a sort for each safety area can be provided. The safety committee can then review these particular operations to determine if corrective action is necessary to meet a new standard, apply lessons-learned from a previous test failure, etc. This report has become an excellent operational tool since it provides visibility to management and the Safety Organization of the potential hazards for research operations.

## EMERGENCY RESPONSE TEAM

The emergency response team at the Center is composed of the Plant Protection staff, Medical Services staff and Emergency Reaction Team personnel. The Plant Protection staff, consisting of two 11-man firefighting units each on 24-hour shifts, provides first response to fire and medical emergencies. The firefighters are also trained and certified as Emergency Medical Technicians (EMT-A). They also provide building fire inspections, industrial safety inspections, oil spill containment, investigate vehicle accidents and safety checks of facility and research systems. In the event of multiple emergencies or when additional manpower is required, Emergency Reaction Team (ERT) members are called. The ERT, whose members are usually technicians, is composed of five 5-man teams, an off-shift team of 15 members and a special services team of 5 members. The Medical Services staff, composed of a doctor and two nurses, provides occupational health and emergency medical services during the regular work shift. The emergency response team, in total, provides a very comprehensive, fast and capable response to the entire Center.

## CONCLUSION

In closing, the effectiveness of any safety program depends on the support of management and employees and must address the basic operational needs of the organization. The Lewis Research Center has developed a Safety Organization and a structural systems safety approach for addressing the high potential risks of research operations. Over the years, a safety permit control system has provided visibility of risk to management and assurance that research test operations do not commence until safety approval is granted. This structural systems safety approach is believed to be a major contributor to the excellent Center safety record.

## REFERENCES

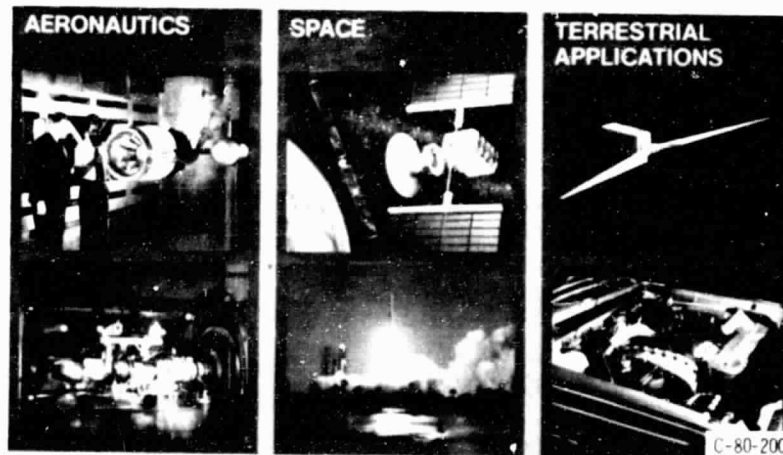
1. NASA Safety Manual. Volume 1: Basic Safety Requirements, NHB-1700.1, National Aeronautics and Space Administration, 1969.
2. NASA Systems Safety Manual. Volume 3: System Safety. NHB-1700.1, National Aeronautics and Space Administration, 1970.
3. NASA Lewis Research Center Operational Safety Manual.
4. Wiggins, James, Boeing Corp., Houston, Texas: System Safety Course Presented at NASA Lewis Research Center, June 16-20, 1980.





C-80-109

Figure 1. - Lewis Research Center Physical Plant.



C-80-200

Figure 2. - Lewis Research Center Charter.

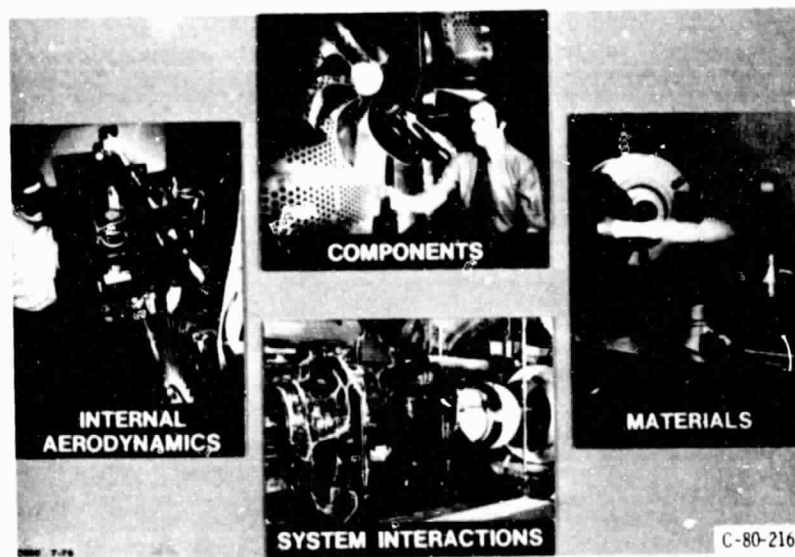


Figure 3. - Lewis Research Center Aeronautical Propulsion R&T.

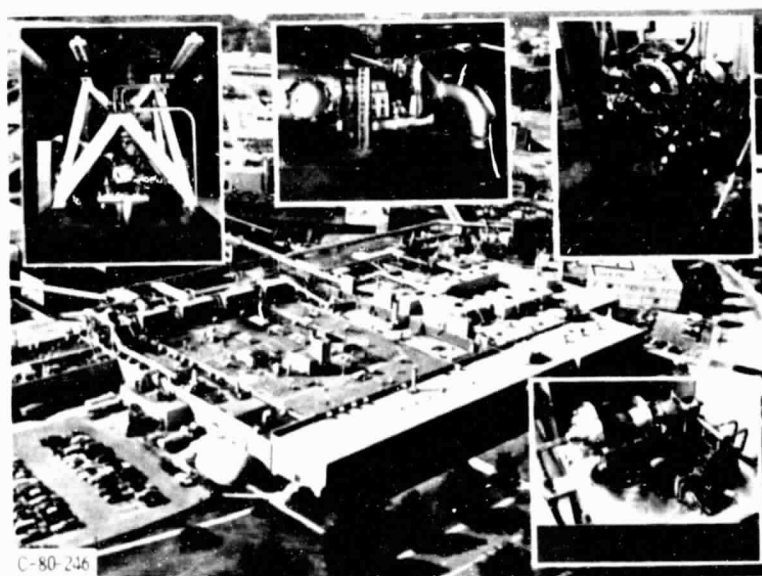


Figure 4. - Lewis Research Center Engine Research Building.

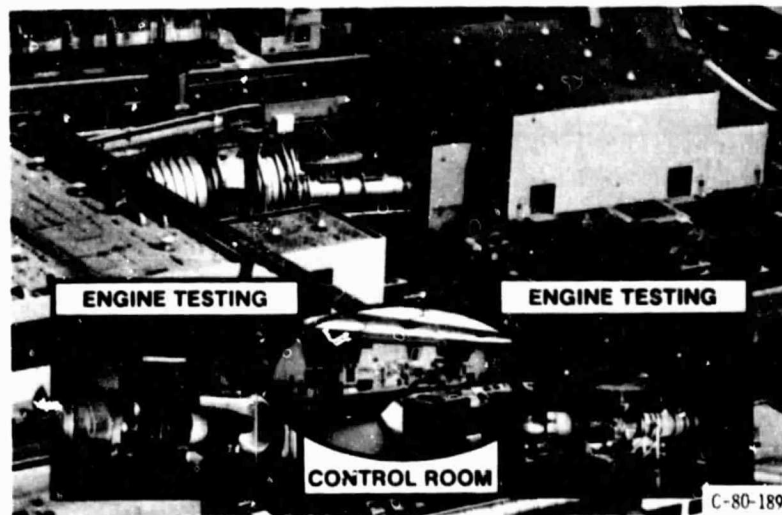


Figure 5. - Lewis Research Center Propulsion System Laboratory's 3&4.

#### KEY ELEMENTS OF THE CENTER SAFETY PROGRAM

- Management support and visibility
- Centerwide safety policy and organization
- Systems safety approach
- Review performed by professional scientists, engineers and safety-health specialists independent in-line responsibilities
- A documented review-approval system for each research operation with potential hazards

FIGURE 6

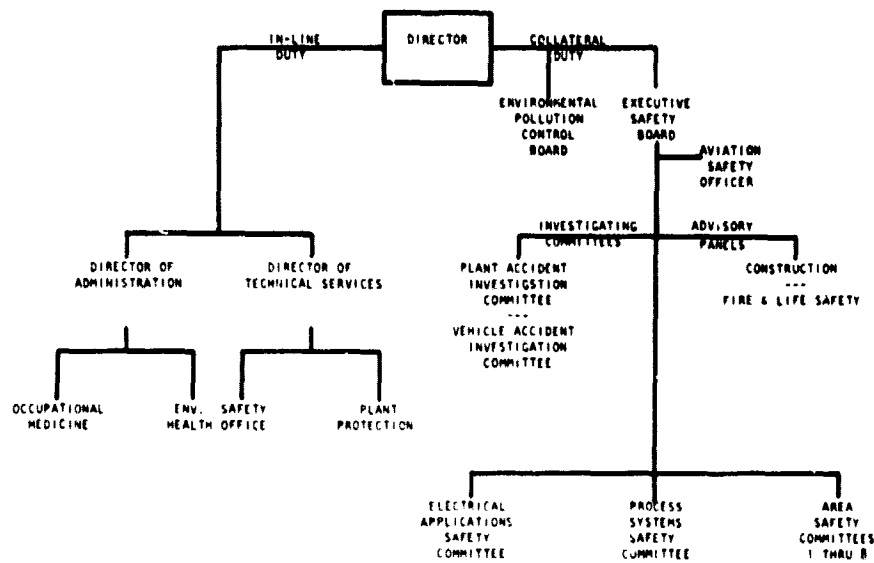


Figure 7. - Lewis safety organization.

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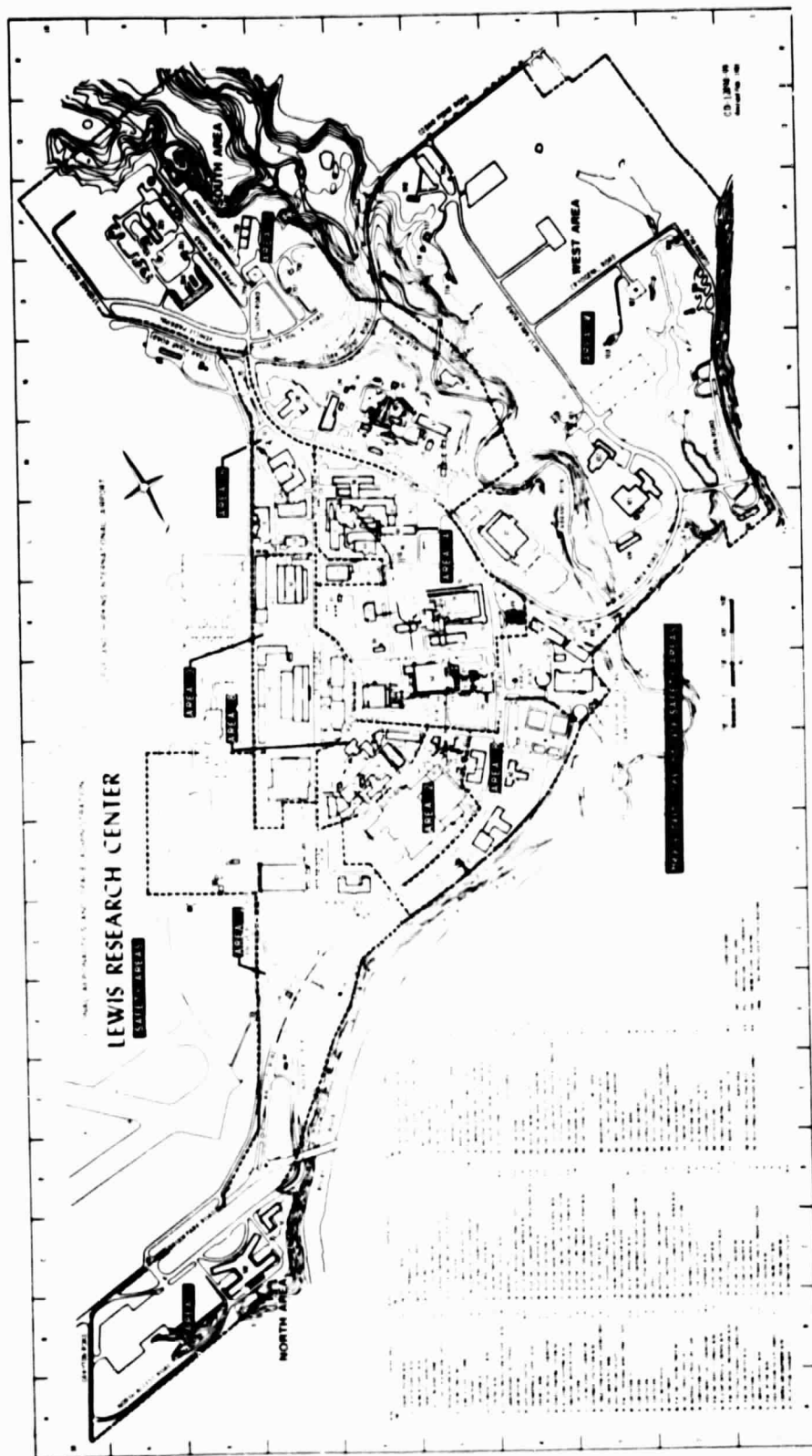


Figure 8. - Lewis Research Center safety areas.



Figure 9. - Who are the players in the safety review and approval process?

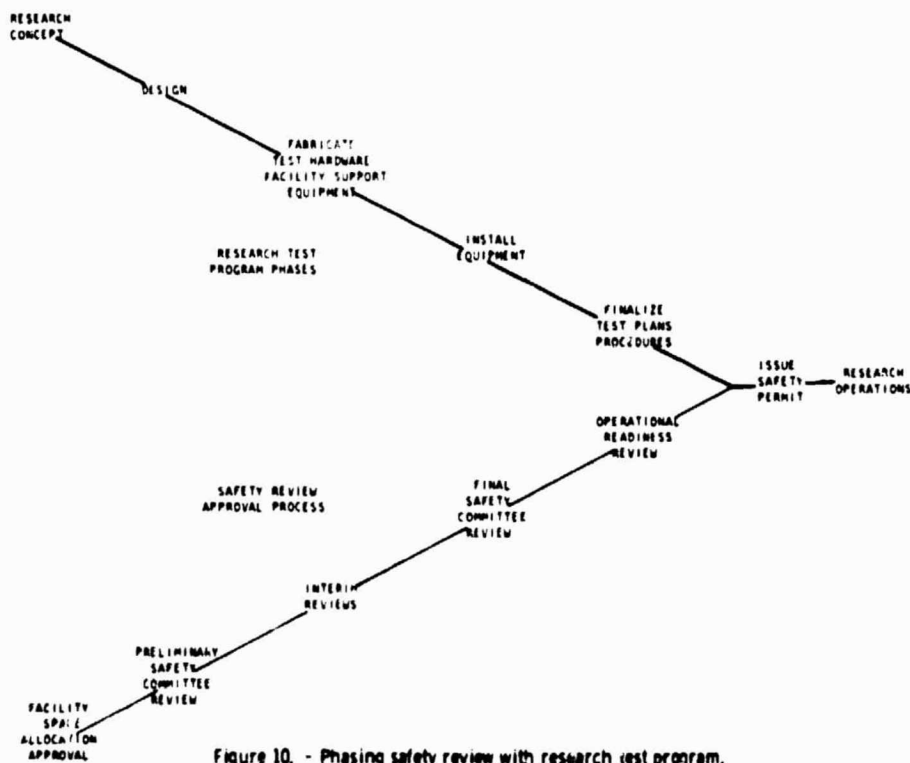


Figure 10. - Phasing safety review with research test program.

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1. Safety Permit Request.
2. Description of test rig, facility, test support equipment, research hardware.
3. Schematic diagrams or key drawings including a plot plan.
4. Operational procedures.
5. Hazards identification analysis with failure severity assessment.
6. Design codes, margins, operating limits.
7. Emergency Plan.
8. Certification and training for qualified operators.
9. Level of buddy system.

Figure 11. - Content of a systems safety plan.

TYPE	DEFINITION	TIME TO APPLY	DATA REQUIRED
PRELIMINARY HAZARD ANALYSIS(PHA)	A gross hazard analysis identifies hazardous elements and conditions and provides rationale for design, test and procedural requirements.	•Perform during conceptual phase. Update through life of the program.	•System Concept Data •Operational Data •Operating Environment
FAULT HAZARD ANALYSIS(FHA)	Determine the effect of various subsystem component failures upon the subsystem, system or personnel.	•Top level during preliminary design phase. •Detailed prior to critical design review and operational readiness review.	•Drawings, specs, hardware system descriptions •Schedule •FMEA (if available) •Historical data
FAILURE MODE EFFECTS ANALYSIS (FMEA)	A reliability design evaluation technique for documenting potential single failures in a system, determine effect of failure and rank failure by severity and probability.	•Same as for FHA	•Same as for FHA
OPERATING HAZARD ANALYSIS (OHA)	Address system interfaces such as man, machine, environment, and management. Identifies hazards associated with the dynamics of these interfaces and provides rationale for development of control measures.	•After design is finalized. •During development of procedures.	•Final design specs, drawings •First draft procedures •FHA •System descriptions •Historical data
FAULT TREE ANALYSIS (FTA)	A fault tree is a graphical representation of a logical thought process. •Top level fault tree  •Detailed fault tree	•Concept phase •Final program assessment •Accident investigation  •For total system •For selected events	•System data •Schematics •Operational data •Other analyses •Same as above

Figure 12. - Types of hazard analyses.

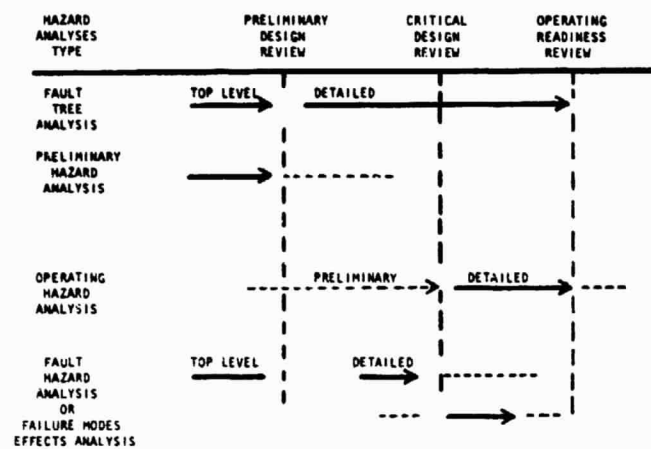


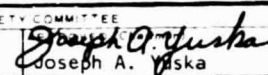


Figure 13. - Phasing hazard analyses techniques.



NOTE: COPY OF SAFETY PERMIT REQUEST MUST BE POSTED WITH THIS PERMIT.

 National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio		<h1 style="margin: 0;">SAFETY PERMIT</h1>							
LOCATION (Room, building, cell, etc.) <b>Bldg. 125 PSL-3</b>		DRAWING NOS. <b>CF505683 CR505682 CC505740</b>							
ACTIVITY (Describe research operation, facility equipment, etc., requiring safety approval.) <b>Perform heat transfer and performance tests on a 2DCD versatile non-axisymmetric nozzle on a J-85-13 engine.</b>		SAFETY AREA PERMIT NO. <b>4-401</b> DATE ISSUED <b>5/81</b> EXPIRATION DATE <b>5/82</b> WORK UNIT (MINI-TASK) <b>Y0F4T13</b> REPLACES PERMIT NO. <b>NEW</b> <div style="text-align: center; margin-top: 10px;">   <b>TAKE ACTION USE Water, Dry Chemicals, or CO<sub>2</sub></b> </div>							
		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="text-align: left;">EMERGENCY CONTACT</th> <th style="text-align: left;">HOME PHONE</th> </tr> <tr> <td>(Knowledgeable person) <b>R. Solomon</b></td> <td><b>XXXXXXXX</b></td> </tr> <tr> <td>(Alternate) <b>F. Boecker</b></td> <td><b>XXXXXXXX</b></td> </tr> </table>		EMERGENCY CONTACT	HOME PHONE	(Knowledgeable person) <b>R. Solomon</b>	<b>XXXXXXXX</b>	(Alternate) <b>F. Boecker</b>	<b>XXXXXXXX</b>
EMERGENCY CONTACT	HOME PHONE								
(Knowledgeable person) <b>R. Solomon</b>	<b>XXXXXXXX</b>								
(Alternate) <b>F. Boecker</b>	<b>XXXXXXXX</b>								
ACTIVITY APPROVED FOR SAFETY SUBJECT TO THE FOLLOWING CONDITIONS: <ol style="list-style-type: none"> <li>1. The "buddy system" per the Lewis Operational Safety Manual shall be adhered to in all phases of test operations.</li> <li>2. The engine/facility must be at steady state condition while the required walk-arounds are conducted.</li> </ol>									
SAFETY APPROVAL REQUESTED BY (Project Engineer's name) <div style="text-align: center; margin-top: 10px;"><b>R. Solomon, PAX 6256</b></div>									
AREA SAFETY COMMITTEE REVIEWED BY <b>Area 4 Comm</b>		ACTIVITY COMPLETED DATE _____ SIGNATURE _____ <div style="text-align: center; margin-top: 10px;">   <b>Joseph A. Yaska</b> </div>							
<b>INSTRUCTIONS</b>									
Area Safety Committee Chairman After approval of the Safety Permit Request (NASA-C-919), complete this permit in accordance with procedures prescribed in LMI 1703.1 and send one copy to each of the following for: <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <div style="width: 45%;"> <b>CLEVELAND</b>            Project engineer (Resp. Eng.)            Office of Environmental Health (When applicable)            Safety Office         </div> <div style="width: 45%;"> <b>PLUM BROOK</b>            Lewis Safety Officer            Project engineer (Resp. Eng.)            Plum Brook Management Office         </div> </div>		Project Engineer (Responsible Engineer) <ol style="list-style-type: none"> <li>1. Post a copy of this Permit, together with a copy of the Safety Permit Request and a copy of the Safety Permit Renewal Request (when applicable) at the location described.</li> <li>2. Submit a new Safety Permit Request (NASA-C-919) at least 30 days prior to the expiration date if:             <ol style="list-style-type: none"> <li>a. the activity will not be completed by the expiration date.</li> <li>b. no change is made to the operation as described in this Permit.</li> </ol> </li> <li>3. Submit a Safety Permit Renewal Request (NASA-C-590) at least 30 days prior to the expiration date if:             <ol style="list-style-type: none"> <li>a. the activity will not be completed by the expiration date.</li> <li>b. no change is made to the operation as described in this Permit.</li> </ol> </li> <li>4. When the activity is completed, remove this permit, indicate the completion date, and send it to the cognizant Area Safety Committee chairman.</li> </ol>							

NASA-C-919 (Rev. 4-78)

NASA-Lewis

Figure 14. - Safety permit.

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<b>SAFETY PERMIT REQUEST</b>		<b>SAFETY COMMITTEE USE ONLY</b>	<b>DATE</b> 5/1/81	<b>Permit No.</b> PREVIOUS _____ NEW <b>4-401</b>																																							
<b>T O</b> AREA SAFETY COMMITTEE NO. <u>4</u>		<b>EMERGENCY CONTACT</b> (Knowledgeable person) _____ (Alternate) _____		<b>HOME PHONE</b>																																							
<b>R O</b> PROJECT ENGINEER NAME (Responsible Engineer) Robert F. Solomon		<b>ORG. CODE</b> 2131	<b>PAX</b> 6256	<b>PBX</b> 227	<b>MAIL STOP</b> 500-208																																						
<b>1. ACTIVITY (Describe research operation, facility, equipment, etc., requiring safety approval.)</b> Perform heat transfer and performance tests on a 2DCD versatile non-axisymmetric nozzle on a J-85-13 engine																																											
<b>2. LOCATION (Room, building, cell, etc.)</b> PSL-3 Bldg. 125		<b>3. DRAWING NOS.</b> Drawings supplied at review		<b>4. WORK UNIT NO. (Task)</b> YOF4113																																							
<b>5. TESTS (Nature of objectives, etc.)</b> Heat transfer and performance of a versatile non-axisymmetric nozzle in afterburning and non-afterburning modes at various geometry arrangements and using three cooling techniques.																																											
<b>6. EXPECTED DURATION DATES</b> START <u>4-10-81</u> COMPLETE <u>6-1-81</u>			<b>7. TEST RUNS</b> LENGTH <u>6 Hrs.</u> TIME: <input checked="" type="checkbox"/> WORKDAY <input type="checkbox"/> NIGHT <input type="checkbox"/> WEEKEND																																								
<b>8. TEST CONDITIONS (List the most hazardous conditions, use of fluids, power, radiation, etc.)</b> <table border="1" style="width: 100%; border-collapse: collapse; margin-top: 5px;"> <thead> <tr> <th rowspan="2">MATERIAL, FLUID, ETC.</th> <th rowspan="2">VOLTAGE, PRESSURE, ETC.</th> <th rowspan="2">FREQUENCY, TEMPERATURE, ETC.</th> <th colspan="2">QUANTITY</th> <th rowspan="2">REMARKS</th> </tr> <tr> <th>AT SITE</th> <th>IN VEG.</th> </tr> </thead> <tbody> <tr> <td>Jet A fuel</td> <td>80 PSIG</td> <td>Amb temp</td> <td></td> <td></td> <td></td> </tr> <tr> <td>GN2</td> <td>2400 PSIG</td> <td>Amb temp</td> <td>70,000 SFC</td> <td></td> <td></td> </tr> <tr> <td>Comb air</td> <td>40 PSIG</td> <td>Amb temp</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Cool. air</td> <td>150 PSIG</td> <td>Amb temp</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Hyd. fluid</td> <td>2500 PSIG</td> <td>125 Deg F.</td> <td></td> <td></td> <td>MIL-5606</td> </tr> </tbody> </table>						MATERIAL, FLUID, ETC.	VOLTAGE, PRESSURE, ETC.	FREQUENCY, TEMPERATURE, ETC.	QUANTITY		REMARKS	AT SITE	IN VEG.	Jet A fuel	80 PSIG	Amb temp				GN2	2400 PSIG	Amb temp	70,000 SFC			Comb air	40 PSIG	Amb temp				Cool. air	150 PSIG	Amb temp				Hyd. fluid	2500 PSIG	125 Deg F.			MIL-5606
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<b>9. MATERIAL DESCRIPTION (XXX) (Mark for materials to be used.)</b> <table style="width: 100%;"> <tr> <td style="width: 33%;"><input type="checkbox"/> TOXIC</td> <td style="width: 33%;"><input type="checkbox"/> CORROSIVE</td> <td style="width: 34%;"><input type="checkbox"/> MEDICAL MONITORING REQUIRED FOR PERSONNEL</td> </tr> <tr> <td><input type="checkbox"/> PYROPHORIC</td> <td><input type="checkbox"/> RADIOACTIVE</td> <td><input type="checkbox"/> EXPLOSIVE</td> </tr> <tr> <td colspan="3"><input type="checkbox"/> OTHER (Specify) _____</td> </tr> </table>						<input type="checkbox"/> TOXIC	<input type="checkbox"/> CORROSIVE	<input type="checkbox"/> MEDICAL MONITORING REQUIRED FOR PERSONNEL	<input type="checkbox"/> PYROPHORIC	<input type="checkbox"/> RADIOACTIVE	<input type="checkbox"/> EXPLOSIVE	<input type="checkbox"/> OTHER (Specify) _____																															
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<input type="checkbox"/> PYROPHORIC	<input type="checkbox"/> RADIOACTIVE	<input type="checkbox"/> EXPLOSIVE																																									
<input type="checkbox"/> OTHER (Specify) _____																																											
<b>10. DESCRIPTION OF RADIATION AND OR RADIOACTIVE MATERIAL (Complete and attach Users Radiological Training &amp; Experience Record, NASA-C-197, for each user.)</b> <table style="width: 100%;"> <tr> <td style="width: 33%;"> <b>PHYSICAL FORM</b>  <input type="checkbox"/> SEALED SOURCE  <input type="checkbox"/> UNSEALED SOURCE  <input type="checkbox"/> GAS  <input type="checkbox"/> LIQUID  <input type="checkbox"/> SOLID       </td> <td style="width: 33%;"> <b>TYPE OF RADIATION</b>  <input type="checkbox"/> ALPHA <input type="checkbox"/> GAMMA  <input type="checkbox"/> BETA <input type="checkbox"/> NEUTRON  <input type="checkbox"/> OTHER (Describe, if such as X-ray producing equipment) _____       </td> <td style="width: 34%;"> <b>ELEMENT OR COMPOUND</b> _____  <b>ELEMENT OR COMPOUND WEIGHT</b> _____  <b>RADIOACTIVE ISOTOPE</b> _____  <b>WEIGHT OF RAD. ISO. IN ELEMENT COMP.</b> _____  <b>ACTIVITY CURIES</b> _____       </td> </tr> </table>						<b>PHYSICAL FORM</b> <input type="checkbox"/> SEALED SOURCE <input type="checkbox"/> UNSEALED SOURCE <input type="checkbox"/> GAS <input type="checkbox"/> LIQUID <input type="checkbox"/> SOLID	<b>TYPE OF RADIATION</b> <input type="checkbox"/> ALPHA <input type="checkbox"/> GAMMA <input type="checkbox"/> BETA <input type="checkbox"/> NEUTRON <input type="checkbox"/> OTHER (Describe, if such as X-ray producing equipment) _____	<b>ELEMENT OR COMPOUND</b> _____ <b>ELEMENT OR COMPOUND WEIGHT</b> _____ <b>RADIOACTIVE ISOTOPE</b> _____ <b>WEIGHT OF RAD. ISO. IN ELEMENT COMP.</b> _____ <b>ACTIVITY CURIES</b> _____																																			
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<b>11. RADIATION DETECTION INSTRUMENTS</b>  																																											
<b>INSTRUCTIONS</b> If required (See LMI 1703-1), attach pertinent drawings, hazards analysis and/or Users and Experience Record (NASA-C-197)																																											
At Cleveland, send copy of this request with backup material as required to Office of Environmental Health. After completion of investigation and/or sign off by OEH, Request shall be submitted to cognizant Area Committee Chairman Through the Requester.			At Plum Brook Station, send copy with backup material as required to the Plum Brook Management Office, and one copy of Request only to the Lewis Safety Office.																																								

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Figure 15. - Safety permit request.

12. IS THERE A PRECEDENT FOR THIS WORK? (If "Yes", give details.) <input checked="" type="checkbox"/> YES <u>Nozzle Tests in PSL-2</u> <input type="checkbox"/> NO <u>Himat tests in PSL-3</u>		13. NASA-C-197 (attached) YES <input type="checkbox"/> NO <input type="checkbox"/> (Name) _____			
14. DISCHARGE PRODUCTS (Radioactive, corrosive, combustible, toxic and air-water pollution materials.)					
PRODUCTS: Temperature Radioactive, Noise, Toxic, Hazards (Quantity or Degree)	MEANS OF COPING WITH DISCHARGE PRODUCTS (Abatement Device or Treatment Process)	EFFLUENT DISCHARGED TO	SAMPLING FREQUENCY	TYPE OF DETECTION	MONITORING GROUP
Combustion products up to 1,000 Deg. F. max. mixed gas temp.	Exhaust cooling with dry cooler followed by a spray cooler	PSL Equip. Building	None		
15. SAFETY PRECAUTIONS (Indicate what provision has been made for the following typical items.)					
SITUATION		SAFETY PRECAUTION			
A Ventilation		N/A for test chamber; building has ventilation fans.			
B Detection of hazardous condition (Radiation, toxicity, etc.)		N/A			
C Ignition sources		Test chamber: Engine and its ignitors. Appropriate facility electrical codes.			
D Safe location of personnel during tests		All personnel in control rooms, except when on inspection rounds.			
E Avoidance of unsafe contamination of fuel or oxidant		N/A			
F "Fail Safe" means in case of power, pressure, combustion or personnel failure		List of contingencies in program review writeup.			
G Protective means in case of over-temperature, over pressure, or over speed		Yes, listed in review writeup.			
H Accident Procedure (Fire, explosion, spill)		For fire, stop fuel and comb. air flow, go to alt. and/or inert cell with CO <sub>2</sub> .			
I Collapse of vessel from evacuation		N/A			
J Personnel protection (Protective clothing, breathing apparatus, medical check, etc.)		N/A			
K Grounding		Proper grounding and shielding provided in facility			
L Grounding of live parts		N/A			
M Shielding (Radioactive material, radiation producing equipment, and high frequency radiation)		N/A			
N Hazard - warning signs		Appropriate signs posted			
O Level of buddy system		Buddy System per LMO 1704.1B			
16. SPECIAL ITEMS (List pertinent items peculiar to conditions of proposed test)					
REQUESTING DIVISION CHIEF (Signature) <i>Robert F. Solomon</i>		DATE 4/3/81		OFFICE OF ENVIRONMENTAL HEALTH (Signature) <i>David J. Follen</i>	
DATE 4/3/81		OFFICE OF ENVIRONMENTAL HEALTH (Signature) <i>David J. Follen</i>		DATE 4/3/81	

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Figure 15A. - Safety permit request.

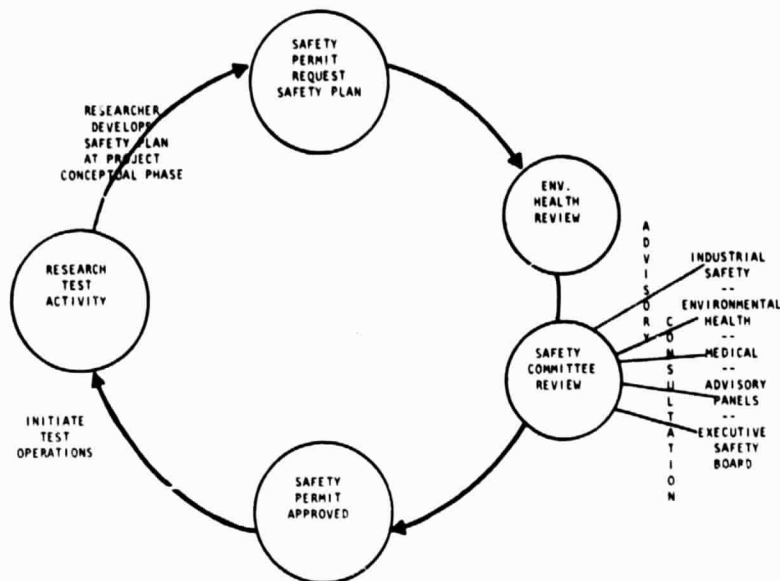


Figure 16. - Flow chart for safety permit review and approval process.

JOB NO. 30024-B

BUILDING NO. 16 ELECTRIC PROPULSION RESEARCH																JAN. 17, 1975										PAGE 29					
LOCATION BLDG ROOM	TASK RTG	S U	DESCRIPTION	PHD ENGINEER	SAFETY PERMITS	SAFETY ITEMS										OTHER SAFETY	FLOOR SPACE	UTILITIES										SC			
						A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U	V	W	X	Y	Z	
0016 140	02	YAC0016 A	REDINGER ELECTRICAL SHOP BUILDUP AREA		N/A																										A
0016 146	01	YOS4001 A	HANKS GRID FABRICATION -ION THRUSTER-		101 09/75																										A
0016 146	02	YOS4005 A	HANKS 2000 DEGREE FURNACES		102 09/75																										C
0016 150	01	YOV5176 A	COLES HOMOPOLAR GENERATOR		74 08/75																										A
0016 150	02	YAC0016 A	HAGEDORN CORLIN NEON COMPRESSOR		N/A																										A
0016 150	03	YOV4717 A	MEYN WATER MAGNET MAGNETIC FIELD STUDIES		73 08/75																										A
0016 150	04	YAC0016 A	HAGEDORN INGERSOLL RAND HELIUM COMPRESSOR		N/A																										C
0016 156	01	YAC0016 A	HAGEDORN HE COMPRESSOR PLANTS 1 & 2 & HE PURIFIER		121 11/75																										AU
0016 156	02	YAC0016 A	HAGEDORN CVI HELIUM GAS PURIFIERS		115 11/75																										AU
0016 160	01	YOV4708 A	MORGAN NEON CRYOMAGNETS 1 & 2 SUPPORT SYSTEMS		114 10/75																										H
0016 160	02	YOV4078 A	MORGAN MHD INITIAL MAGNET CHECKOUT TESTS		120 10/75																										H
0016 160	05	YOV4078 A	JENTNER MHD TEST SUPPORT SYSTEMS		N/A																										H
0016 166	01	YAC0016 A	REDINGER UTILITY SERVICE		N/A																										A
0016 168	01	YAC0016 A	REDINGER MODEL PREPARATION & ASSEMBLY AREA		N/A																										A
0016 170	01	YAC0016 A	HAGEDORN NEON PLANT		N/A																										L
0016 170	02	YAC0016 A	REDINGER MAGNET ASSEMBLY AREA		N/A																										A

\*SAFETY LEGEND\*  
 A-HYDROCARBONS B-N-VOLATILE C-H.S. ROTATION D-H. PRESS GAS  
 E-RADIATION F-MERCURY G-NITROGEN H-LASER I-TOXIC MATERIAL  
 J-CRYOGENICS K-HYDROGEN L-NITROGEN M-TOXIC MATERIAL  
 N-CAUSTIC O-5-150 PSI C.A.T P-NATURAL GAS  
 Q-1-650 PSI C.A.T R-1-650 PSI C.A.T S-1-650 PSI C.A.T  
 T-1-650 PSI C.A.T U-1-650 PSI C.A.T V-1-650 PSI C.A.T  
 W-1-650 PSI C.A.T X-1-650 PSI C.A.T Y-1-650 PSI C.A.T  
 Z-1-650 PSI C.A.T

Figure 17. - Technical Services Facilities Utilization Report by location.

1. Report No <b>NASA TM-81772</b>		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle <b>SAFETY MANAGEMENT OF COMPLEX RESEARCH OPERATIONS</b>				5. Report Date	
				6. Performing Organization Code <b>None</b>	
7. Author(s) <b>William J. Brown</b>				8. Performing Organization Report No. <b>E-832</b>	
				10. Work Unit No.	
9. Performing Organization Name and Address <b>National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135</b>				11. Contract or Grant No.	
				13. Type of Report and Period Covered <b>Technical Memorandum</b>	
12. Sponsoring Agency Name and Address <b>National Aeronautics and Space Administration Washington, D.C. 20546</b>				14. Sponsoring Agency Code	
15. Supplementary Notes <b>Prepared for the Fifth International System Safety Conference, Denver, Colorado, July 30, 1981.</b>					
16. Abstract <p>Complex research and technology operations present many varied potential hazards which must be addressed in a disciplined independent safety review and approval process. The research and technology effort at the Lewis Research Center is divided into programatic areas of aeronautics, space and energy. Potential hazards vary from high energy fuels to hydrocarbon fuels, high pressure systems to high voltage systems, toxic chemicals to radioactive materials and high speed rotating machinery to high powered lasers. A Safety Permit System presently covers about 600 potentially hazardous operations. The Safety Management Program described in this paper is believed to be a major factor in maintaining an excellent safety record at the Lewis Research Center.</p>					
17. Key Words (Suggested by Author(s)) <b>System safety Safety management Research facilities</b>			18. Distribution Statement <b>Unclassified - unlimited</b>		
19. Security Classif. (of this report) <b>Unclassified</b>		20. Security Classif. (of this page) <b>Unclassified</b>		21. No. of Pages	
				22. Price*	

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